Bendix
Aerospace Systems Division

Antenna Aiming Mechanism

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TDK

Performance/Design and Product Configuration Requirements - Antenna Aiming Mechanism For Array E, ALSEP

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1.0 SCOPE

This specification establishes the performance, design, and testing requirements for an antenna aiming mechanism for the Data Subsystem of Array E of the Apollo Lunar Surface Experiments Package (ALSEP).

2.0 APPLICABLE DOCUMENTS

The following documents of issue shown form a part of this specification to the extent specified herein. Should conflicting requirements exist, the requirements of this specification shall govern.

Specifications

Military

MIL-STD-130C	Identification marking of U. S. Military Property.
MIL-STD-143B	Specifications and Standards Order of Precedence for the selection of
MIL-STD-889	Metals, defintion of dissimilar
MIL-STD-810B	Environmental Test Methods of Aerospace and Ground Equipment
MIL-STD-721B	Definition of effectiveness terms for reliability, maintainability, human factors, and safety

Grumman Aircraft Engineering Corporation (GAEC) Documents

LED 520-1F	Design Criteria and Environments for the LEM
LIS 360-22101	LEM Scientific Equipment Materials Compatibility Requirements

NASA/MSC Criteria and Standards

DS-1	System Accessibility for Maintenance
DS-8	Mechanical Rigging Devices
PS-8	Application of Previous Qualification Tests
PS-11	Direct Procurement of Parts
NHB 5300.4(1B)	Quality Program Provisions for Aeronautical and Space Contractors
DS-12	Single point failure
DS-21	Meteoroid Environment in near-earth, cislunar, and near-lunar space

Drawings

BxA 2348609	Interface Control Drawing, ALSEP Aiming Mechanism, Array E
TM 661	ALSEP Flight System Qualification test plan, Array E
TM 662	ALSEP Flight Acceptance test plan, Array E
TP 2365562	Functional test procedure, Antenna Aiming Mechanism, Array E

Other Publications

Bendix ATM-242 Revision E	Approved Materials List
Bendix ATM-964	ALSEP Array E Component Non-operating Vibration Specifications

3.0 REQUIREMENTS

3.1 Performance. - The antenna aiming mechanism shall be designed to support and aim the data subsystem antenna. The aiming mechanism will be transported to the lunar surface aboard the Apollo Lunar Module (LM), and stowed on the Apollo Lunar Surface Experiment Package (ALSEP). The astronaut will provide assembly to the antenna and antenna mast and proper alignment of the aiming mechanism while on the lunar surface.

3.1.1 Operational Characteristics

3.1.1.1 Attachment Method. - For deployment purposes there shall be easy attachment between the aiming mechanism, the antenna mast, and the antenna. When detached, the aiming mechanism shall be capable of being stowed in the aiming mechanism stowage envelope as shown in BxA Drawing 2348609 (ICD).

3.1.1.2 Leveling Adjustment. - The leveling of the aiming mechanism shall have a range of ±10° on two right angle axes. Leveling adjustments shall be accomplished with a thumbwheel and screw on each axis. The levelness of each axis shall be indicated by a tubular (linear) bubble level which is in a position to be read from the vertical. The bubble levels shall have a sensitivity of 15 minutes of arc per 0.10 inch of bubble movement and reference marks to indicate when the axis is within 15 minutes of arc of being level.

3.1.1.3 Sun Compass Adjustment. - The sun compass adjustment shall have a range of ±15° minimum about the vertical axis from the null position. The sun compass shall have a two way gnomon attached to the latitude gimbal (see paragraph 3.1.1.4 for description) such that proper latitude adjustment tilts the gnomon into the lunar equatorial plane. Once tilted into the lunar equatorial plane, sun compass adjustment shall be independent of apparent sun angle; requiring only matching of the gnomon shadow to the reference for proper east-west alignment of the mechanism. The sun compass post shall be designed such that no additional support or protection is necessary. Sun compass adjustment shall be driven by 72:1 worm and worm gear.

3.1.1.4 Latitude Adjustment. - The latitude adjustment shall have a range of 0-45° from vertical and adjustments shall always be made in a direction toward the lunar equator. The adjustments shall be made by a worm and worm wheel gear with a gear ratio of 36:1. The latitude reading shall be made from an angle indicating dial attached to the gimbal shaft and from a counter driven by the worm gear. The dial and counter shall be indexed as shown in figure 2.

3.1.1.5 Longitude Adjustment. - The longitude adjustment shall have a range of ±60° from Gimbal Centerline. The adjustment shall be made by a worm and worm wheel gear with a gear ratio of 36:1. The longitude reading

shall be made from an angle indicating dial attached to the gimbal shaft and from a counter driven by the worm gear. The dial and counter shall be indexed as shown in figure 1. The longitude adjustment range shall be positioned such that longitude setting will not cause the antenna to cast a shadow over the sun compass or longitude adjustment disturb the sun compass setting once the latitude setting and sun compass alignment have been made. At no setting shall any part of the aiming mechanism be above any part of the antenna ground plane.

3.1.1.6 Override Mechanism. - The longitude, latitude and sun compass adjustments shall be provided with disengagement mechanisms which allow the astronaut to override the worm gear system. Disengagement or engagement of the mechanism shall be accomplished with 90° of operating lever rotation. When disengaged and the antenna is being manually positioned, the dial angle indicator shall be used to indicate proper setting. The mechanical accuracy of antenna positioning in the override operation mode shall be 5° or better in each axis.

3.1.1.7 Aiming Accuracy. - The tolerances on mechanical fit, thermal warpage, and alignment errors shall be such as to measure a total aiming error of no more than that shown in Table 1.

3.1.1.8 Scale Requirements. - A digital readout for all scales is required as shown in figure 1.

3.1.2 Operability.

3.1.2.1 Reliability. - Reliability shall be a prime consideration in design, development, and fabrication Redundancy will be utilized in achieving the reliability goal. The design will provide maximum resistance to a single point catastrophic failures. As a goal, the aiming mechanism shall have a .99% probability of surviving launch, translunar flight, and lunar surface operation (including deployment) in the environment specified in paragraph 3.1.2.4 herein.

3.1.2.2 Maintainability. - Equipment arrangements, accessibility, and interchangeability features shall be incorporated into the design to allow efficient preinstallation servicing and maintenance. The requirements of DS-1 and DS-8 are applicable. The aiming mechansim shall be designed to be an individually replaceable unit.

3.1.2.3 Useful life. - The aiming mechanism shall be capable of performing as specified herein during all phases of lunar day and lunar night for a period of 2 years after a maximum storage period of 3 years.

3.1.2.4 Environment. - The aiming mechanism shall be designed to be capable of performing as specified in paragraph 3.1 herein, during or after as applicable, being subjected to the most severe environmental conditions shown herein or any logical combination of these environments applied simultaneously. Appropriate levels are given for Design, Qualification Testing,

and Acceptance Testing in subsequent subparagraphs. Inspection, qualification testing, acceptance testing, and functional verification shall be performed as described in paragraph 4.1 and 4.2. The aiming mechanism shall meet or exceed the following environmental specifications.

3.1.2.4.1 Atmospheric Conditions

3.1.2.4.1.1 Relative Humidity

Design Environment

Storage (packaged): per paragraph 3.3.11 for 3 years.

Shipment (packaged): 100% maximum

Factory and Launch Pad: 50% maximum normal,

100% maximum for 3 days (in stowed configuration)

Flight and Lunar Operation: Not required.

Qualification testing and acceptance testing:

Not Required.

3.1.2.4.1.2 Sand and Dust-During Deployment

Design Environment

Design for Lunar Operation per LED 520-1. Note that aiming mechanism will be stowed in foam capsule.

Qualification Testing and Acceptance Testing:

Not Required.

3.1.2.4.2 Acceleration - Stowed Configuration

Design Environment

Design for 14g±1.0g, 1 minute duration.

Qualification and Acceptance Testing

Not required

3.1.2.4.3 Sinusoidal Vibration - Stowed Configuration

Design Environment

Design for Levels specified in ATM-964

Qualification Testing

Test per TM 661 (SYSTEM TEST)

Acceptance Testing

Test per TM 662 (SYSTEM TEST)

3.1.2.4.4 Random Vibration - Stowed Configuration

Design Environment

Design for Levels specified in ATM-964

Qualification Testing

Test per TM 661 (SYSTEM TEST)

Acceptance Testing

Not required.

3.1.2.4.5 Shock - Stowed Configuration

Design Environment

Design for 20g, 11 Millisecond Sawtooth Per Mil. Std. 810B

Qualification Testing

Test per TM 661 (SYSTEM TEST)

Acceptance Testing

Not required

3.1.2.4.6 Temperature

Design Environment

Storage: per paragraph 3.3.11 for 3 years

Lunar Stay: -300°F to +250°F

Lunar Operation and Deployment: -65°F to +160°F

Qualification Testing

Test per TM 661 (SYSTEM TEST)

Acceptance Testing

Test per TM 662 (SYSTEM TEST)

3.1.2.4.7 Radiation - Lunar Stay (deployed)

Design Environment

Per LED-520-1

Qualification testing and acceptance testing

Not required.

3.1.2.4.8 Solar Radiation - Lunar Stay (deployed)

Design Environment

Per LED-250-1

Qualification Testing and Acceptance testing

Not required

3.1.2.4.9 Vacuum

Design Environment

Lunar Stay: less than 10^{-12} mm Hg

Flight: less than 10^{-8} mm Hg for 4 days

Shipment, factory, launch pad, and storage: sea level to 50,000 ft.

Qualification testing

Test per TM 661 (SYSTEM TEST)

Acceptance testing

Test per TM 662 (SYSTEM TEST)

3.1.2.4.10 Meteoroids - Lunar Stay (deployed)

Design Environment

Provide micrometeoroid protection in accordance with NASA Criteria DS-21 for 2 years.

Qualification testing and Acceptance testing

Not required.

3.1.2.4.11 Acoustics - Flight (stowed)

Design Environment

Per LED-520-1, 5 minutes

Qualification testing and Acceptance testing

Not required.

3.1.2.4.12 Thermal - Vacuum (deployed)

Design Environment

Per paragraph 3.1.2.4.6 and 3.1.2.4.9

Qualification Testing

Test per TM 661 (SYSTEM TEST)

Acceptanct Testing

Test per TM 662 (SYSTEM TEST)

3.1.2.5 Ground handling and transportability. - Provisions shall be made to protect from corrosion, contamination, or structural damage due to handling in accordance with paragraph 3.1.2.5 of Exhibit B, ALSEP Array E Technical Specification Applies.

3.1.2.6 Human factors. - The aiming mechanism design is constrained by the following astronaut requirements:

3.1.2.6.1 Assembly and adjustment time. - The total time for astronaut assembly of the antenna to aiming mechanism and aiming mechanism to mast shall be no greater than 2.0 minutes as a design goal. Antenna aiming will be performed near the end of the ALSEP deployment period, and shall require no more than 4.0 minutes as a design goal.

3.1.2.6.2 Leveling. - The antenna reference plane shall be leveled through the use of two thumbwheels. Astronaut error in reading the leveling indicator, shall be included in overall leveling error allowed (See table I).

3.1.2.6.3 Leveling Thumbwheels. - Leveling thumbwheels shall be designed for use by the astronaut while wearing thermal gloves. The thumbwheels shall be alike and be of no less than 1.25 inches in diameter and no less than 1/4 inch in width. Surface of the thumbwheel skirts shall be knurled and scalloped. Wheels shall lie in approximately the same plane. which shall be parallel to the lunar surface. Distance between nearest edges of the two wheels shall be at least 1 inch. As a design goal. Torquing requirements shall not exceed 7.6 in-lbs.

3.1.2.6.4 Longitude and Latitude. - The aiming mechanism shall be aligned in longitude and latitude through the use of adjustment knobs. The mechanism is properly aligned in longitude and latitude when the dial angle

indicator and vernier counter indicate the longitude and latitude of the deployment site in degrees. The vernier counter shall be used in conjunction with the dial angle indicator to provide the required adjustment accuracy. Latitude setting shall be made prior to sun compass setting to allow proper orientation of the gnomon.

3.1.2.6.5 Sun Compass. - The aiming mechanism shall be aligned east-west through the use of a sun compass adjustment knob (which moves the mechanism in azimuth) and a gnomon or sun dial. The mechanism is properly aligned to the lunar east-west when the gnomon shadow is coincident to the reference on the sun compass.

3.1.2.6.6 Alignment knobs. - Alignment knobs shall be designed for use by the astronaut while wearing thermal gloves. The three knobs (sun compass, longitude, and latitude) shall be alike and of no less than 1.25 inches in diameter and no less than 0.25 inch in width. The surface of the knob skirt shall be knurled and scalloped identically to that of the leveling thumbwheels. Clearance from edges of the knobs shall be not less than 1 inch as a design goal. Torque required to be applied to the knobs by the astronaut shall not exceed 7.6 in.-lbs.

3.1.2.6.7 Override Mechanisms - Engagement levers shall be designed for use by the astronaut while wearing thermal gloves. Rotation required for engagement or disengagement shall be no more than 90°. The three levers (sun compass, longitude, and latitude) shall be no less than 1 inch in length (measured from axis of rotation) and no less than 0.25 inch in width. Clearances from the edge of the levers and surround projections shall be as large as possible.

With an engagement lever in the disengaged position, the aiming mechanism can be rotated about that axis by hand to the desired position, re-engaged, and locked within ±5 degrees of the desired setting. Operation in the override mode is a contingence operation only. This operating mode can destroy the indexing between the dial angle indicator and the vernier counter. Torque required for engagement or disengagement on the engagement level shall not exceed 9.6 inch-lbs.

3.1.2.6.8 Astronaut work area requirements. - Design of aiming mechamism components shall be such as to permit the standing astronaut to perform antenna assembly and adjustment tasks easily from a position near the corner of the central station at which the aiming mechanism is attached. Design shall conform to the anthropometric constraints of astronaut movement indicated in Section 3.1.2.6.17 below. As a design goal, no controls or indicators shall be capable of moving out of the immediate reach or view of the astronaut due to adjustment of another control.

3.1.2.6.9 Height of controls and indicators. - No control knob, thumbwheel lever, adjustable sleeve, scale, or other visual indicator shall be located lower than 38 inches above the lunar surface.

3.1.2.6.10 Readability of visual indicators. - All visual indicators shall be readily readable from a maximum distance of 34 inches. Numerals shall be a minimum of .09 inch high condensed gothic numerals, qraduation marks and numeral-graduation mark separation shall be at least 0.03 inch. Pointers shall be no more than 0.03 inch from graduation marks. Major graduation marks shall be numbered.

3.1.2.6.11 Interface between aiming mechanism components. - Interface between the antenna aiming mechanism and the antenna mast shall use a keyed coupling which is tapered. Interface between the aiming mechanism and the antenna shall use a keyed quick connect detent fastener.

3.1.2.6.12 Surface: physical contact. - Sharp and abrasive surfaces, edges, corners and protuberances, shall be eliminated in the design of the aiming mechanism. The radius of surface edges shall be greater than 0.03 in.. and preferably greater than 0.125 in.

3.1.2.6.13 Surface: visual aspects. All aiming mechanism external surfaces which might cause problems for the astronaut due to reflection of sunlight should be provided with low reflection properties. Adjustment, control handling and scalar surfaces shall be marked in such a manner as to enhance the contrast quality of those surfaces to the extent this does not affect thermal degradation

design or raise external surface temperature to the point at which thermal degradation can occur. Calibration and alignment indices shall be painted black on a white matte background.

3.1.2.6.14 Surface: visual tasks. Visual tasks shall be designed to the optimum viewing angle of the astronaut in the Extra-vehicular Mobility Unit (EMU-suit), rather than the maximum. The operational viewing angle encompasses a 30-degree cone of vision circumscribed by 15 degrees left and right, 0 degrees up and 30 degrees down from the horizontal line-of-sight. All visual tasks shall be designed for performance within the constraints of the extravehicular protective visor and sun visor. All tasks shall also be designed to make full use of the astronaut's shadow and/or full sunlight as required to obtain the optimum visual advantage.

3.1.2.6.15 Glove. - There shall be no handling requirements necessitating the removal of the thermal outer glove.

3.1.2.6.16 Similarity of operation. - Astronaut tasks shall be as nearly standardized as possible for similar operational functions throughout the ALSEP deployment process in order to reduce the probability of "reversal errors" under stress created by the mission environment fatigue, or other psychophysiological conditions.

3.1.2.6.17 Anthropometric requirements. Consideration shall be given in design of tasks to the requirements contained in the following subparagraphs:

(a) Movement of the arms and hands behind the frontal (y-z) plane and above shoulder height shall be eliminated.

(b) Tasks requiring twisting, turning, or torso rotation shall be eliminated.

(c) Astronaut task shall avoid the necessity for the astronaut to reach to any point within a distance of 22 inches off the lunar surface or more than 66 inches. Any manipulation requirements shall be performed between 28 inches and 60 inches off the ground.

(d) Task and equipment design shall not require the astronaut to assume a neeling or prone position on the lunar surface.

(e) Dynamitric (hand grip squeezing) forces in excess of 10 pounds shall not be required.

(f) Human strength shall be utilized in the design of lifting and transportation tasks to eliminate assistance devices with weight penalities.

(1) Where man's strength is a design factor, restraints shall be incorporated to prevent the astronaut from exceeding the tensile strength of the equipment and the inertia limits. The astronaut can exert a 60 pound static load and dynamic loads as high as 250 lbf under lunar surface gravity conditions in extreme conditions.

(2) Fine adjustment mechanisms shall be constructed of materials capable of withstanding maximum torque loads.

(g) All carrying tasks shall be designed to ensure that the astronaut's feet are not obscured from his vision.

(h) Where latching or unlatching is a requirement of the ALSEP deployment careful attention shall be paid to providing the optimum latch motion.

(i) Manipulative operations requiring the simultaneous use of both of the astronaut's hands, other than for simple holding, shall be limited to heights between 30 and 48, inches off the ground as a design goal.

(j) Any requirements for the astronaut to exert a force in excess of 20 pounds is prohibited.

3.1.2.7 Safety. - Safety requirements shall comply with the limitations of the suited astronaut and the following:

3.1.2.7.1 Personal safety. - The safety of the crew while unloading, transporting, and deploying the equipment on the lunar surface and of personnel while handling the equipment on earth shall be a prime consideration in ALSEP design. This shall include avoidance in equipment design of sharp edges, corners, and protuberances. Inherent protection of personnel from inadvertent contact with high temperature surfaces and hazardous electrical points shall be provided.

3.1.2.7.2 Equipment safety. - Where practicable, the aiming mechanism shall be hermetically sealed or of explosion-proof construction.

3.1.2.7.3 Hazard proofing. - The design of the Aiming Mechanism shall minimize the hazard of fire, explosion and toxicity to the crew, launch area personnel and facilities. The hazards to be avoided include accumulation or leakage of combustible gases, the hazard of spark or ignition sources including static electricity discharge, and toxicity due to inhalation or spillage of volatile or poisonous expendables.

3.1.2.7.4 Nuclear safety criteria. - Not applicable.

3.2.1.7.5 Fail safe. - Part, component, on subsystem failures shall not propagate sequentially.

3.2 Interface requirements. -

3.2.1 Schematic arrangement. - The Aiming Mechanism interface is schematically shown in Figure 2.

3.2.2 Detailed interface definition. -

3.2.2.1 Aiming Mechanism-to-Mast. - The mechanical interface between the aiming mechanism and the antenna mast shall consist of the following:

(a) The antenna aiming mechanism shall be designed to be compatible with mounting requirements on the mast.

(b) Provision shall be made so that there can be no rotation of the antenna assembly when mounted on the antenna mast.

(c) The aiming mechanism-to-antenna mast interface shall be as shown in BxA Drawing 2348609, Interface Control Drawing, ALSEP Aiming Mechanism, Array E.

3.2.2.3 Antenna-to-Aiming Mechanism. - The mechanical interface between the antenna and the antenna aiming mechanism shall consist of:

(a) The antenna ground plane shall contain a keyed fitting for accurate alignment and mounting on the aiming mechanism and so that the antenna will not rotate on this mechanism.

(b) The antenna to aiming mechanism connection shall be made with a "quick connect" fastener to permit rapid assembly by the astronaut.

(c) The aiming mechanism-to-antenna interface shall be as shown in BxA Drawing 2348609 Interface Control Drawing, ALSEP Aiming Mechanism, Array E.

3.2.2.4 Aiming Mechanism Stowage. - During stowage, the antenna and aiming mechanism shall be separated.

The stowed configuration for the aiming mechanism will consist of a foam capsule which will completely enclose the aiming mechanism, except for the tapered antenna mast connection. The foam capsule shall

be rigidly clamped to a baseplate. The foam capsule shall remain with the aiming mechanism until it is deployed. The capsule shall then be removed in two half-sections. For shock and vibration design purposes, the aiming mechanism shall be considered to be rigidly supported at all points.

The mounting fixtures are considered to be part of the stowage compartment(s) and are not included as part of the aiming mechanism.

3.3 Design and Construction. - The aiming mechanism shall be designed to be lightweight and to meet or exceed the environmental and functional performance requirements specified herein.

3.3.1 General Design Features. -

3.3.1.1 Form Factor. - The dimensions of the antenna aiming mechanism shall be not larger than those shown in Figure 1.

3.3.1.2 Weight. - The weight of the aiming mechanism shall not exceed 1.80 pounds.

3.3.1.3 Center of Gravity. - The center of gravity for the aiming mechanism shall be indicated in the interface control drawing (ICD).

3.3.2 Selection of Specifications and Standards. - All standards or specifications, other than those established and approved for use by NASA must be approved by Bendix prior to use.

3.3.3 Materials and Processes. - Materials shall be selected from the ALSEP Approved Materials List—ATM-242E. All materials and processes shall be compatible with the intended use and enivronment requirements specified in 3.1.2.4 herein.

3.3.3.1 Materials. - Materials used in the fabrication of all components shall be of the highest quality compatible with design requirements specified herein. In general, the following types of materials shall not be used without prior written approval of NASA:

(a) Flammable materials

(b) Toxic materials

(c) Unstable materials

(d) Plastic—(only epoxy resin - based compounds, teflon, and mylar shall be used).

(e) Dissimilar metals in direct contact which tend toward active electrolytic or galvanic corrosion.

3.3.3.2 Standard Processes

3.3.3.2.1 Protective Treatment. - All materials used which are not inherently corrosive-resistant shall be treated to resist any corrosive effects resulting from environmental conditions specified herein. Protective coatings shall not crack, chip, peel, or scale with age when subjected to the environmental extremes specified. Finishing, coating and marking materials shall conform to ATM 242E.

3.3.4 Standard Parts-Mechanical. - NASA Standard, Air Force-Navy (AN), Military Standards (MS) or joint Air Force-Navy (JAN) mechanical parts shall be used where applicable.

3.3.4.1 Standardization. - Maximum economic standardization of parts and components shall be provided. Where identical or similar functions are performed in more than one application within the system, effort shall be made to use only one item design for all system applications.

3.3.4.2 Parts Procurement. - The requirements of PS-8 and PS-11 (excluding serialization requirement, Part C) shall apply. Bendix shall be capable of identifying at any time the manufacturer's lot from which parts have been procured.

3.3.5 Moisture and Fungus Resistance. - Materials which are not nutrients for fungus shall be used wherever possible. The use of materials which are nutrients for fungus shall not be prohibited in hermetically sealed assemblies and in other accepted and qualified uses. If it is necessary to use fungus nutrient materials in other than such qualified application, these materials shall be treated with a process which will render the resulting exposed surface fungus resistant.

3.3.6 Corrosion of Metal Parts. - Metals shall be corrosion-resistant type or suitable treated to resist corrosive conditions likely to be met in

storage or normal service. Unless suitably protected against electrolytic corrosion, dissimilar metals, as defined in Standard MIL-STD-889, shall not be used in direct physical contact.

3.3.7 Interchangeability. - Interchangeability shall be compatible with the requirements of paragraph 3.1.2.2 herein. Items of equipment with the same part numbers shall be physically and functionally interchangeable, as defined in MIL-STD-721.

3.3.8 Workmanship. - The aiming mechanism shall be constructed, finished and assembled in accordance with highest standards.

3.3.9 Electromagnetic Interference (EMI). - Only if applicable.

3.3.10 Identification and Marking. - The aiming mechanism shall be marked for identification in accordance with Standard MIL-STD-130.

3.3.10.1 Nameplate Data. - The nameplate shall include but not be limited to the following data:

(a) Item nomenclature

(b) Item part number and revision letter

(c) Item serial number

(d) Identification of non-electrical functioning (simulator) models

(e) Data of manufacture

3.3.11 Storage. - The aiming mechanism shall have a shelf life of three years. Shelf life is defined as a storage period in a controlled environment of 50°F to 80°F and a relative humidity of no more than 50 percent following acceptance and prior to installation in the LM for flight.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Inspection. - In addition to drawing compliance, the following requirements of Section 3 of the specification shall be verified by an inspection of the aiming mechanism at time and place of acceptance testing:

3.3.1.1 Form Factor

3.3.1.2 Weight

3.3.1.3 Center of Gravity

3.3.3.2 Standard Processes. -

3.3.4 Acceptable Parts. -

3.3.8 Workmanship. -

3.3.10 Identification and Marking. -

4.2 Tests. - The following requirements in Section 3 of this specification shall be verified during development, qualification and acceptance testing.

4.2.1 Functional Tests. - During development testing, the following functional characteristics shall be evaluated throughout the mechanism's environmental operating range:

(a) Smoothness and range of travel about each axis.

(b) Torque required for lever and knob manipulation.

(c) Interface compatability.

(d) Aiming accuracy.

In association with qualification and acceptance testing, the functional characteristics shall be evaluated per TP 2365562

4.2.2 Environmental Tests. - The following environmental specifications given in paragraph 3.1.2.4 shall be verified by development testing:

3.1.2.4.3 Sinusoidal Vibration. -

3.1.2.4.4 Random Vibration. -

3.1.2.4.5 Shock. -

3.1.2.4.6 Temperature. -

3.1.2.4.9 Vacuum. -

3.1.2.4.12 Thermal Vacuum. -

The environmental specifications shall be further verified by qualification and acceptance testing as denoted in paragraph 3.1.2.4.

4.2.3 Demonstration Tests. - The following requirements of section 3 of this specification shall be verified by demonstration tests during development:

3.1.2.6 Human performance. -

3.1.2.7 Safety. -

4.3 Reliability

4.3.1 Reliability Test and Analysis. - The requirements of paragraph 3.1.2.1 of this specification shall be verified by analysis.

4.3.2 Analysis. - The following requirements of Section 3 of this specification shall be verified by review of analytical data:

3.1.2.2 Maintainability

3.1.2.3 Useful Life

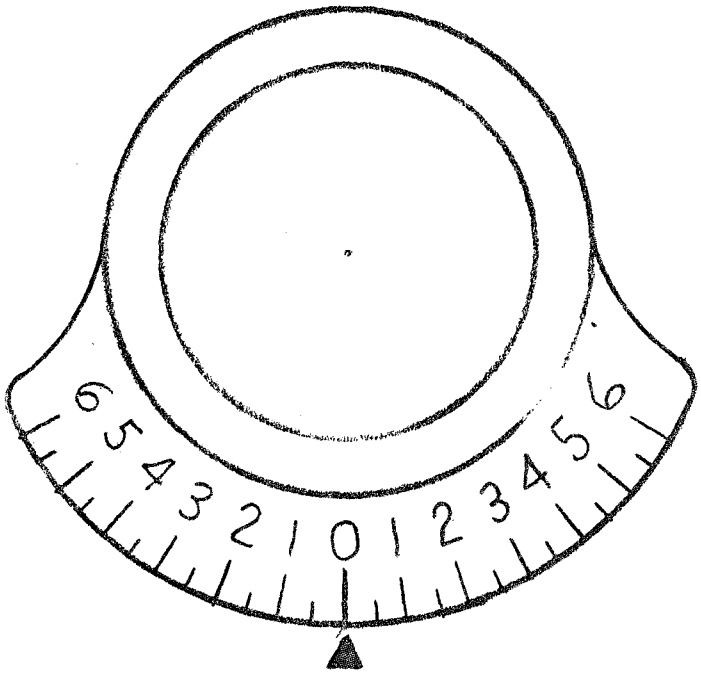
3.3.11 Storage

Error Source	Maximum Allowed Error
1. Aiming Mechanism Manufacturing Error	0.14°
(a) Misalignment of Longitude & Latitude	
(b) Misalignment of Sun Compass	
(c) Misalignment of Level Bubble	
2. Antenna Boresight Calibration Error	0.20°
3. Antenna to Aiming Mechanism (Gimbal) Assembly Error	0.10°
4. Astronaut Alignment Errors:	
(a) Scale Setting (Each Axis)	0.25°
(b) Leveling	0.50°
(c) Shadow Alignment	0.70°
5. Equivalent Pattern Distortion due to Proximity of Central Station	0.10°
6. Pattern Distortion due to Antenna Droop with Age (creep)	0.10°
7. Antenna Thermal Distortion	0.10°
8. Aiming Mechanism Thermal Distortion	0.50°
9. Mechanical Backlash	0.25°

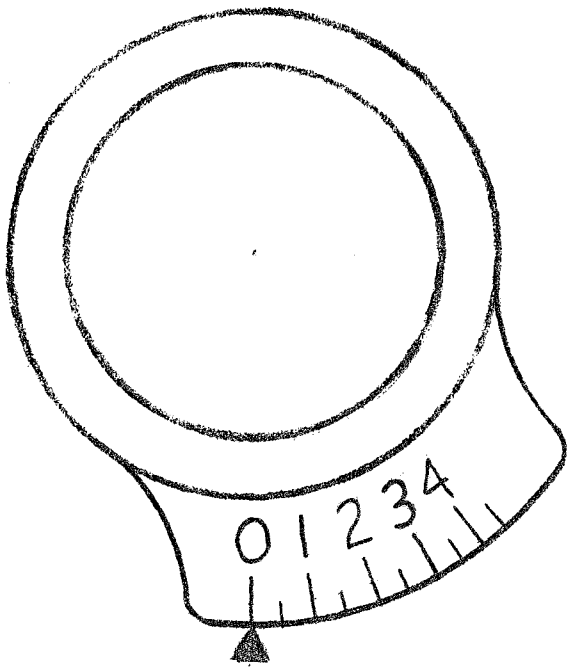
Root-sum-square of all Antenna Assembly Errors = 1.16°

NOTE: The errors here are based on a statistical distribution of the individual errors. In all cases the individual errors were taken as the worst case so that the overall error should approximate a 3 sigma error. However, the number of times that the Antenna Assembly is deployed does not approach a statistical sample. Therefore, the real objective here is to maximize the probability of correct aiming on each occasion. This will necessitate keeping the individual errors as low as is physically possible.

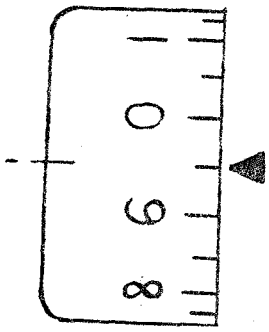
Table 1 - Allowable Antenna Assembly Pointing Error Tabulation



Longitude Dial
Angle Indicator
± 60°
24 Divisions
5° per Division



Latitude Dial
Angle Indicator
0-45° 40
8 Divisions
5° per Division



Vernier Drum
10° per Division
20 Divisions
0.5° per Division

Figure 1. Scale Readout Requirements

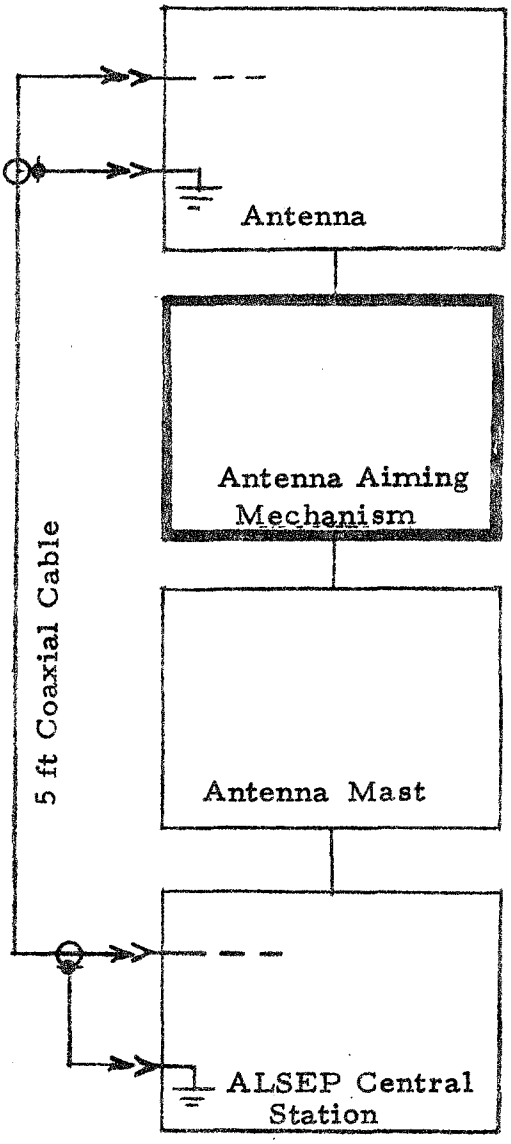


Figure 2. Aiming Mechanism Interface Schematic